5.0 DOCUMENTATION ASSESSMENT

This portion of ASP-I provides an assessment of the completeness of available model documentation and the compliance of each component to a set of proposed, tailored standards; recommendations for bringing the documentation into compliance with those standards; and implications of the current state of documentation on model use and verification and validation (V&V) efforts. This assessment provides the model manager with specific information on how the documents can be improved and also provides the model user with a quick description of the adequacy of the documentation set.

The standards against which the documentation were assessed were derived from a study sponsored by the SMART Project and documented in a report entitled Software Verification Requirements Study (SVRS) for the SMART Project [Ref. 36]. The SVRS describes the minimum set of documents and content standards required to assist a potential user to evaluate the suitability of an existing model for a specific purpose and ensure that it has been rigorously verified against known standards and procedures. These documents should allow the potential user to: have confidence that the model is accurate; decide if the model simulates the problem(s) of concern; have sufficient information to install and run the program(s); modify the model to work on the target platform (if necessary); understand all inputs and outputs; and fix problems during model use, either due to runtime errors, incorrect input, or incorrect program operation.

The starting point for formulating these recommendations was DOD-STD-2167A, Defense System Software Development, which established requirements to be met by government contractors for the acquisition, development, or support of software systems. This document grew out of the need to standardize and manage the development of computer software in the DoD community and it includes requirements for software documentation. After an extensive search for, and review of, government requirements and guidelines, the following documents were identified as the minimum set necessary for mature model verification: Software User's Manual (SUM), Software Programmer's Manual (SPM), Software Analyst's Manual (SAM), Software Design Document (SDD), and Software Verification Report (SVR).

The SUM and SPM formats described in DOD-STD-2167A were tailored for digital simulation models. The SAM is not addressed by 2167A; therefore, its format was generated after a review of other sources. Electronic Combat Digital Evaluation System (ECDES) Model Documentation and Programming Guidelines were also used as guidelines for implementing DOD-STD-2167A. The existing SAMs for ESAMS, ALARM, and RADGUNS were also used to provide guidance for the recommendations. The SDD and SVR typically do not exist for mature models. However, SMART has sponsored tasks to support the development of equivalent documents for several models: the Conceptual Model Specifications (CMSs) and Verification Reports (VRs).

RADGUNS v.2.0 was found to have one of the recommended documents, namely, a User Manual [Ref. 11]. The Supplement to User Manual [Ref. 12] has information applicable to a SAM. Much information applicable to the SPM and SAM is in the Methodology and Design Manual (MDM) [Ref. 38]. It should be noted that RADGUNS is a mature model that has evolved for over 20 years. Like many models with similar histories, an SDD was never written during on-going model development. An SDD is necessary to conduct

verification of the model since an SDD sets forth the requirements to be verified as being correctly implemented. As part of the SMART Project Verification and Validation (V&V) effort for RADGUNS, a SDD substitute has been written. This document, called the Post-Development Design Document for RADGUNS [Ref. 7], was developed and renamed as the Conceptual Model Specification (CMS) upon incorporation into Accreditation Support Package (ASP-II). The SVR is a report of a verification effort. A substitute for the SVR, the Verification Report (VR), has been developed and is included in ASP-III. Updated CMSs and VRs will be written as the enhancement and verification of RADGUNS proceeds under the SMART Project. Table 5-1 summarizes the assessment of existing RADGUNS documentation.

The documentation assessment for RADGUNS focuses on the distributed Version 2.0 documentation [Refs. 2, 3, and 4]. Table 5-1 summarizes the assessment of existing RADGUNS documentation with respect to fulfilling requirements for a standard SUM, SPM, and SAM.

TABLE 5-1. Documentation Assessment Summary for RADGUNS.

Characteristic	**SUM**	**SPM (Portions in Published MDM)**	**SAM (Portions in Published MDM and Supplement to SUM)**
Publication Date	February 1996	February 1996	February 1996
Applicability	Version 2.0	Version 2.0	Version 2.0
Completeness	Adequate (Complete except for list of error messages and detailed discussion of assumptions and limitations)	Adequate (Complete except for error detection and diagnostics, detailed call hierarchy, dictionary of variables, discussion of global variables)	Adequate (Complete except for equation/algorithm description for all subfunctions, subfunction input and output, and detailed assumptions and limitations)
Compliance	Complies (Except for some minor modifications)	Does not Comply	Does not Comply

Notes: The characteristics and adequacy of the model documentation are summarized in the above table using the following criteria:

* Completeness — The completeness of the documentation is stated as “Complete,” “Adequate,” (the implication being incomplete, but adequate), “Inadequate,” or “Nonexistent.”

* Compliance — The compliance of the documentation with referenced standards is stated as “Complies” or “Does Not Comply.”

* Applicability — The version of the model the documentation represents is stated as “Current” (the latest version) or “Version (n.n.n).”

5.1 COMPLETENESS

Tables 5-2 through 5-4 provide summaries of the completeness of the existing RADGUNS manuals from the perspective of a standard SUM, SPM, and SAM; summaries are detailed by elements required for each section. Summing the results, out of a total of 44 content elements, 11 were included and complete, 24 were included but partially complete, and 9 were not included.

5.1.1 Completeness of Software User's Manual

The RADGUNS SUM has most of the information required for a standard SUM. Most of the information for the standard SUM can be copied from the existing RADGUNS SUM; however, reformatting and content additions are required for a standard SUM. The most serious deficiencies are the lack of a list of error messages and a comprehensive discussion of assumptions and limitations. Table 5-2 summarizes the contents of the RADGUNS SUM.

TABLE 5-2. Contents Summary of SUM for RADGUNS.

Software User's Manual	Complete
Title Page and Preliminary Information	P
1.1 Identification	Y
1.2 System Overview	Y-SUM, MDM
1.3 Document Overview	P
2.0 Referenced Documents	Y
3.1 Initialization	Y
3.2 User Inputs	Y
3.3 Links To Other Programs	Y
3.4 Outputs	P
4.0 Error Messages	N
5.0 Terms and Abbreviations	P
Appendix A: Detailed Assumptions and Limitations	P- MDM

Notes:

Y	Included and Complete	SUM	Software User Manual
P	Partial Treatment	MDM	Methodology and Design Manual
P-XXX	Partial Treatment in other manuals	Y-XXX	Complete but in other manuals

5.1.2 Completeness of Software Programmer's Manual

The RADGUNS MDM has much of the information required for a standard SPM, but much information also needs to be developed. Some information of the standard SPM can be copied from the MDM; therefore, reformatting and content additions will be required. The most serious deficiencies are the lack of an adequate description of error detection and diagnostic features, detailed call hierarchy, a dictionary of variables, and the discussion of global variables (common blocks). Table 5-3 shows completeness for each standard SPM section.

TABLE 5-3. Contents Summary of SPM for RADGUNS.

Software Programmer's Manual	Complete
Title Page and Preliminary Information	P- MDM
1.1 Identification	Y- MDM
1.2 System Overview	P- SUM, MDM
1.3 Document Overview	N
2.0 Referenced Documents	N
3.1 Equipment Configuration	Y- SUM, MDM
3.2 Operational Information	P- SUM
3.3 Compiling and Linking Instructions	P- SUM
4.1 Introduction to Programming Information	P- SUM
4.2 Call Hierarchy	Y- MDM
4.3 Dictionary of Variables	P- MDM
4.4 Global Variables	P- MDM
4.5 Program, Subroutine, and Function Descriptions	P- MDM
4.6 Error Detection and Diagnostic Features	N
5.0 Terms and Abbreviations	N
Appendix A: Detailed Call Hierarchy	N

Notes:

N	Not Included		
Y	Included and Complete	SUM	Software User Manual
P	Partial Treatment	MDM	Methodology and Design Manual
Y-XXX	Complete but in other manuals	P-XXX	Partial Treatment in other manual

5.1.3 Completeness of Software Analyst's Manual

The RADGUNS MDM and Supplement to User Manual [Ref. 12] has much of the information required for a standard SAM; in fact, most of the existing functional implementation methodology information is detailed enough for a standard SAM. The existing information needs to be reformatted and reviewed for typographical errors and cross-referencing errors. Not all areas of functionality are described, so a lot of information needs to be added for a complete standard SAM. The most serious deficiencies are that only a portion of the model functionality has methodology descriptions. Table 5-4 shows the completeness for each SAM section.

TABLE 5-4. Contents Summary of SAM for RADGUNS.

Software Analyst's Manual	Complete
Title Page and Preliminary Information	P- MDM
1.1 Identification	Y- MDM
1.2 System Overview	P- SUM, MDM
1.3 Document Overview	N

TABLE 5-4. Contents Summary of SAM for RADGUNS.

Software Analyst's Manual	Complete
2.0 Referenced Documents	N
3.1 Functional Description Overview	P- MDM
3.2.1 Assumptions and Limitations	P- MDM
3.2.2 Descriptions of Overall Methodology	P- MDM
3.3 Detailed Functional Implementation Methodology	
a. Equations and Algorithms	P- MDM
b. Equations for Variables	P- MDM
c. Inputs and Outputs	P- MDM, SUM2
d. Module Correlation with Functionality	P- MDM
e. Impact on Model Results	P- MDM
4.0 Terms and Abbreviations	N
Appendix A: Detailed Assumptions and Limitations	P- MDM
Other Appendices	Y- SUM2

Notes:

Y	Included and Complete	SUM	Software User Manual
P	Partial Treatment	SUM2	Supplement to SUM
N	Not Included	MDM	Methodology and Design Manual
Y-XXX	Complete but in other manuals	P-XXX	Partial Treatment in other Manuals

5.2 COMPLIANCE

This section presents RADGUNS documentation standards and documentation compliance discussions for accomplishing these standards. Information related to a standard SUM, SPM, and SAM was assessed for compliance using the standards summarized in the following sections. Details of this assessment are presented below.

5.2.1 Software User's Manual

The purpose of the SUM is to provide information and instructions enabling the user to execute a model. It should describe the execution steps, the expected output, and necessary actions when error messages appear. The SUM also provides an introduction to the model. The SUM facilitates the capability to operate the model correctly and to obtain the background for a deeper understanding of the model. The model should be described at a high-level using summarized theoretical information.

5.2.1.1 Standards

The recommended format and contents for a SUM are described in [Ref. 36] and repeated below:

> **Title Page and Preliminary Information**. A SUM Title Page should include the following information: Model Name, Version Number, Volume Number (if applicable), Development Agency, Contractor Name and Address, Contract and CDRL Numbers (if applicable), Date Published, Distribution and Destruction Notices (if applicable), and Document Control Number (DCN). The term "Prepared by" should preface the listing of the Contractor Name and Address.

In addition to the Title Page, a Foreword (Abstract), Table of Contents, List of Tables, and List of Figures should also be provided.

SECTION 1: INTRODUCTION

1.1 Identification. Identify the exact model title, its acronym or abbreviation, the version number, and any other official model identification information.

1.2 System Overview. State the purpose of the model. Include its mission, a general description of the physical systems simulated, and a general description of the intended scenarios. Provide overviews of all major modes of operation and scenarios corresponding to each mode. Auxiliary programs used to generate input data or process output data should be acknowledged; such auxiliary software should be detailed in Section 3.3 (entitled "Links to Other Programs").

1.3 Document Overview. List and describe the purpose of each section of the SUM. Also identify any other documents in the document set containing the SUM.

SECTION 2: REFERENCED DOCUMENT

List the title, number, author, publisher, date and classification level (unless all are unclassified) for each document used in generating the SUM, and for all known documentation for this model. Include sources for all documents not available through normal government stocking activities.

SECTION 3: EXECUTION PROCEDURES

Present detailed procedures necessary to run the model. The instruction set should be comprehensible by a user unfamiliar with the software design. Each subsection in this section should describe step-by-step instructions for executing the model, including details of the options available to the user at each step.

3.1 Initialization. Describe the initialization procedures necessary to execute the model. Detail all initialization options.

3.2 User Inputs. Describe user inputs at the file or data set level. Include variable name, format, allowable ranges, units of measure, and definition of each input item.

3.3 Links to Other Programs. Detail model relationships with pre- and post-processors. Describe drivers not considered part of the model, but part of the delivered model package. Discuss any other program with a link to a model.

3.4 Outputs. Detail the expected outputs from the model. This includes narrative reports as well as files. When applicable, give filenames with paths, data format and units of measure.

SECTION 4: ERROR MESSAGES

List each possible error message with a detailed explanation of each message. Provide a definitive course of action for each error message, including instructions for restarting the model.

SECTION 5: NOTES

5.1 Glossary of Terms.

5.2 Abbreviations.

APPENDICES. Appendices may be used for ease in document maintenance or for readability of the core text material. Examples of appendix contents are graphs, sample user interface printouts, and any classified information.

APPENDIX A: DETAILED ASSUMPTIONS AND LIMITATIONS

Appendix A is reserved for describing all model assumptions and limitations. These should be organized by major areas of functionality.

5.2.1.2 Assessment

This section contains recommendations for satisfaction of the SUM requirements identified in Table 5-2. The RADGUNS Version 2.0 User Manual (hereafter referred to as the current SUM) was found to provide a lot of required information, but some work remains to achieve all requirements for a standard SUM. Much of the contents for a standard SUM can be copied directly from the current SUM. Information present in manuals other than the current SUM and information missing from the manual set will be mentioned in the assessment below as appropriate. An implied recommendation for the entire current SUM is that it should be thoroughly reviewed and revised to ensure that it is complete, cross-referenceable, and applicable to Version 2.0.

Title Page and Preliminary Information. The current SUM has the required Title Page information. A Table of Contents is included, but a List of Tables and a List of Figures needs to be generated. The Preface and Executive Summary should be merged into the standard SUM Foreword.

1.0 INTRODUCTION

1.1 Identification. The model identification information is in current SUM, Section 1.1 "Outline of Simulation Capabilities." The headings of "Title, Proponent, and Point of Contact" from that section should be copied to Section 1.1 of a standard SUM. The applicable version is stated as Version 2.0 Beta, 2/96, under the "General Data" header. The version should be included with the model title.

1.2 System Overview. Some system overview information is contained in the current SUM, Section 1.1 under the headers of "Purpose and Description." Section 1.2, "Types of Simulations," provides a very brief discussion of major modes of operation with corresponding scenarios. Sections 2.3.1 - 2.3.5, "Types of Simulations," overviews user-selectable operational capabilities. For example, the user may select to investigate only target detection range with no tracking or gun firing. The paragraphical descriptions of these five sections should be included in standard SUM, Section 1.2. Also, Section 1.2.1, "Major Components of a Weapon System," and Section 1.2.2, "Weapon System Operation," should be included.

MDM, Section 1.3, "Mission," Section 1.5.1 "Purpose of Model," and Section 1.5.2, "Operational Capabilities," should be copied to standard SUM, Section 1.2. Section 1.5.2 is a list of weapon systems modeled and should be renamed as such in standard SUM, Section 1.2. MDM, Section 3.5, "Major Components," provides a good overview of major modes of operation and general associated scenarios. The code implementation references should be deleted after copying it to standard SUM, Section 1.2.

Discussion of several post-processors in current SUM, Sections 2.8 through 2.13 should be briefly reviewed in standard SUM, Section 1.2. IBM PC-compatible spreadsheet data reduction suggestions provided in current SUM, Section 5.4.4 also should be copied to standard SUM, Section 1.2.

1.3 Document Overview. The current SUM does not have a description of the purpose of each section in the manual. Descriptions should be written for

standard SUM, Section 1.3. Also included should be a listing of all RADGUNS documentation distributed with the model which is listed in current SUM, Section 1.1 under the heading "Hardware and Software."

2.0 REFERENCED DOCUMENTS

Page 105 of the current SUM is a bibliography that divides referenced documents into two subsections; also, two footnotes on Page 102 are actually referenced documents not included in the current bibliography. All of these should be merged into one set of references each of which should have a unique reference number. The resulting list should be included in standard SUM, Section 2.0. The reference numbers used throughout the document should be modified as necessary to correlate with appropriate references in the resulting single list.

3.0 EXECUTION PROCEDURES.

3.1 Initialization. Current SUM, Section 2.7 "Simulation Execution" contains initialization instructions necessary to execute RADGUNS. These instructions are provided for the various computer platforms that can host RADGUNS. This information should be incorporated in standard SUM, Section 3.1.

3.2 User Inputs. Current SUM, Section 2.6.1 (pg. 17- 40) explains each item of user input related to the scenario parameter file (filename with a .PAR extension). Section 2.6.2 defines inputs for the user-changeable jammer parameters input file (filename with a .JAM extension). Section 3.1.2 defines inputs for the user-changeable radar cross-section (RCS) data input file (filename with a .RCS extension). Section 3.1.3 defines inputs for the user-changeable target presented/vulnerable area input file (filename with a .PVA extension). The latter two input file data definitions are presented under the "Format" header in their respective sections of the current SUM.

Some of the more complicated user input data are elaborated on in separate subsections. Section 3.1.4 presents instructions on adding target RCS and presented/vulnerable area data. An important user input to RADGUNS is target flight path data. Current SUM Section 3.2 details how to define flight path input for several available flight path options. Section 3.3 describes how to define a hill (for masking purposes). All items identified in the last two paragraphs should be included in standard SUM, Section 3.2.

3.3 Links To Other Programs. Current SUM, Sections 2.8 through 2.13 detail the relationship of RADGUNS with several post-processors. IBM PC-compatible spreadsheet data reduction is described in current SUM, Section 5.4.4. These cited current SUM sections should be included in standard SUM, Section 3.3. This section should be written to elaborate on the briefly-described post-processors recommended for inclusion in Section 1.2 of the standard SUM.

3.4 Outputs. The current SUM, Section 1.2.4 is called "Output of the Models". It is a good introduction to the output files generated during a model run (excludes post-processing description). Section 2.5 "Input/Output File Definitions" identifies the names of output files and provides two examples. Example 1 and Example 2 (of output files generated) should be merged with

current SUM, Section 4, "Examples of RADGUNS Output." The merged set should be included as an appendix to the standard SUM. Section 3.4 details the file format, with units of measure, for scan-by-scan optional output available for two user-specified time periods during autotrack. This is the only detailed description of RADGUNS output files. All outputs need to be detailed, including (as applicable) file names/paths, data format, and units of measure. These should be presented in standard SUM, Section 3.4.

4.0 ERROR MESSAGES

Description of error messages are not provided in the distributed manuals. Detailed descriptions of each error message and a course of action for each should be written for the standard SUM, Section 4.0 including instructions for restarting the program.

5.0 TERMS AND ABBREVIATIONS

A glossary of terms is not in the current SUM and should be generated for inclusion in standard SUM, Section 5.1. A partial list of abbreviations is provided at current SUM page 103. The standard SUM, Section 5.2 should have a list of all abbreviations used in the document.

APPENDIX A: DETAILED ASSUMPTIONS AND LIMITATIONS

Sections 1.5.3 and 2.4 of the MDM are both titled "Assumptions and Limitations." These are general discussion of system- and model-level assumptions and limitations. Detailed assumptions and limitations are presented in separate subsections in the methodology descriptions after Section 2 of the MDM. These descriptions are subdivided by subfunctions of modeled systems. Standard SUM, Appendix A should have assumptions and limitations organized by areas of functionality. Thus, all high-level assumptions and limitations should be subdivided and the detailed ones should be included as subparagraphs of those at higher level. Only a partial list of assumptions and limitations is in the current documentation. A detailed comprehensive discussion of all assumptions and limitations should be included in Appendix A of the standard SUM (same as Appendix A in the standard SAM).

Other Appendices. Current SUM, Section 1.4 is a "Model Deficiency Report (MDR)" template. This template should be a separate standard SUM appendix. Current SUM, Section 2.5 "Input/Output File Definitions" identifies the names of output files and provides two examples. Example 1 and Example 2 (of output files generated) should be merged with current SUM, Section 4 "Examples of RADGUNS Output." The merged set should be included as an appendix to the standard SUM. Current SUM, Section 3.5 has unit conversion definitions which also should be a standard SUM appendix.

5.2.2 Software Programmer's Manual

The purpose of the SPM is to enable a user or programmer to understand the operation of a model; install, maintain, and modify it; and convert it for use on other computer systems. The SPM addresses the software implementation of the model rather than theoretical considerations and it provides a guide to the internal workings of the software. It includes information on compiling and linking the code as well as descriptions of hardware and

software requirements and peculiarities. If hardware or software listed in a SPM is commercially available, its existing documentation should be referenced by document title and number and the manufacturer should be cited.

5.2.2.1 Standards

The recommended format for a SPM is described in [Ref. 36] and repeated below:

Title Page and Preliminary Information. The SPM Title Page should include the following information: Model Name, Version Number, Volume Number (if applicable), Development Agency, Contractor Name and Address, Contract and CDRL Numbers (if applicable), Date Published, Distribution and Destruction Notices (if applicable), and Document Control Number (DCN). The term "Prepared by" should precede the listing of the Contractor Name and Address. In addition to the Title Page, sections covering a Foreword (Abstract), Table of Contents, List of Tables, and List of Figures should also be provided.

SECTION 1: INTRODUCTION

1.1 Identification. Identify the exact model title, its acronym or abbreviation, the version number, and any other official model identification information.

1.2 System Overview. State the purpose of the model. Include its mission, a general description of the physical systems simulated, and a general description of the intended scenarios. Provide overviews of all major modes of operation and scenarios corresponding to each mode. Auxiliary programs used to generate input data or process output data should be acknowledged and described.

1.3 Document Overview. List and describe the purpose of each section of the SPM. Also identify any other documents in the document set containing the SPM.

SECTION 2: REFERENCED DOCUMENTS

List the title, number, author, publisher, date, and classification level (unless all are unclassified) for each document used in generating the SPM and for all known documentation for this model. Include sources for all documents not available through normal government stocking activities.

SECTION 3: PROGRAMMING ENVIRONMENT

3.1 Equipment Configuration. Describe the computing devices and operating systems that the model operates on and under (developmental and target environment). List other software required for model execution. An example of a software requirement is a graphical user interface (GUI).

3.2 Operational Information. Describe hardware/operating system characteristics and capabilities required for the model. This includes details such as storage space for the source code with a complete input set, memory requirements with utilization examples, memory protection features and input/output (I/O) characteristics.

3.3 Compiling and Linking Instructions. Present instructions on compiling and linking the model software, and describe equipment needed for such procedures. Detail applicable names and version numbers of equipment or software.

SECTION 4: PROGRAMMING INFORMATION

4.1 Introduction. Describe in general the applicable programming conventions and style used to develop the model. A short development history emphasizing programming style and convention evolution could be helpful for mature models with a diverse history.

4.2 Call Hierarchy. Present a top-level subroutine call tree. It should branch down only as far as the main routines for each major area of functionality. A comprehensive call hierarchy (probably generated by an automated software tool) should be included in Appendix A.

4.3 Dictionary of Variables. List all variables alphabetically and provide a definition of each (with units of measure). State whether each variable is global or local. If global, give the name of the common block containing it. If local, list the module(s) containing it.

4.4 Global Variables. Global variables are contained in common blocks for programs written in FORTRAN and are called external variables for programs written in C. Other programming languages will have their own conventions for the handling of global variables. Using the convention appropriate to the programming language, list these variables alphabetically. For example, the common blocks from FORTRAN programs should be listed alphabetically. For each block, list the variables contained in it, give a general description of these variables, and list the modules in which it appears. For programs written in other languages, just list the variables alphabetically, give a general description of these variables, and list the modules in which they appear.

4.5 Program, Subroutine, and Function Descriptions. Provide detailed information about each program, subroutine, or function (hereafter called "module"). List modules alphabetically. Library functions should be listed but only briefly described. All other module descriptions should contain the following information in a clear, concise format useful to a programmer tasked with maintaining the model.

a. Give a brief narrative description of the module. Its objective and method for fulfilling the objective should be stated.

b. Give its location in a specified file, its call sequence, security classification level, and size (number of lines of executable code).

c. Provide a list of calls made by the module and calls to the module.

d. Alphabetically list all variables used by the module. For each variable, list its dimension, type, usage as input and/or output, engineering units, a very brief description, and its usage as an argument, local, or common variable. The user can refer to the Dictionary of Variables (Section 4.3) for a detailed description.

e. Detailed Description. Elaborate on the objectives and methods used to fulfill the objectives stated in the brief description in list item "a" above. Provide a reference in the SAM if a theoretical discussion related to the modeled processes is provided.

4.6 Error Detection and Diagnostic Features. Describe model error diagnostics. Provide a table listing each error condition, the routine(s) in which it is utilized, the model variable(s) involved, and the conditions (logic) causing the error. These diagnostics also are summarized in the SUM, Section 4.

SECTION 5: NOTES

5.1 Glossary of Terms.

5.2 Abbreviations.

APPENDICES. Appendices may be used for ease in document maintenance or for readability of the core text material. Examples of appendix contents are subroutine call tree, flow diagrams, sample user interface printouts and any classified information.

APPENDIX A: DETAILED CALL HIERARCHY

Present the complete calling hierarchy in this appendix.

5.2.2.2 Assessment

The SPM for Version 2.0 was not produced; however, the current RADGUNS manuals have much of the information required for a standard SPM. Applicable information in the existing manuals is evaluated below for completeness and compliance with the standard SPM requirements. Most of the applicable topics that are included in the current manuals are described in adequate detail; but, many topics have not been addressed. One prevalent topic does not belong in any portion of the manual set, namely, design requirements. These

sections typically have "Design Requirements" at the end of the title. All such sections should be deleted.

The following paragraphs contain comments regarding the SPM requirements described in Table 5-3. An implied recommendation for the entire current SPM is that it should be thoroughly reviewed and revised to ensure that it is complete, cross-referenceable, and applicable to Version 2.0.

Title Page and Preliminary Information. The SPM Title Page and preliminary information should be written per instructions presented earlier in Section 5.2.2.1 except that the information should be applicable to the SPM.

1.0 INTRODUCTION

1.1 Identification. The model identification information is in current SUM, Section 1.1 "Outline of Simulation Capabilities." The headings of "Title, Proponent, and Point of Contact" from that section should be copied to Section 1.1 of a standard SPM. The applicable version is stated as Version 2.0 Beta, 2/96, under the "General Data" header. The version should be included with the model title.

1.2 System Overview. Some system overview information is contained in the current SUM, Section 1.1 under the headers of "Purpose and Description." Section 1.2 "Types of Simulations" provides a very brief discussion of major modes of operation with corresponding scenarios. Section 1.2.1 "Major Components of a Weapon System" and Section 1.2.2 "Weapon System Operation" should be included in standard SPM, Section 1.2. Sections 2.3.1 - 2.3.5 "Types of Simulations" overviews user-selectable operational capabilities. For example, the user may select to investigate only target detection range with no tracking or gun firing. The paragraphical descriptions of these five sections also should be included in standard SPM, Section 1.2.

MDM, Section 1.3 "Mission," Section 1.5.1 "Purpose of Model," and Section 1.5.2 "Operational Capabilities" should be copied to standard SUM, Section 1.2. Section 1.5.2 really is a list of weapon systems modeled and should have a subsection named as such in standard SPM, Section 1.2. MDM, Section 3.5 "Major Components" provides a good overview of major modes of operation and general associated scenarios. The code implementation references should be deleted after copying it to standard SPM, Section 1.2.

Discussion of several post-processors in current SUM, Sections 2.8 through 2.13 should be briefly reviewed in standard SUM, Section 1.2. IBM PC-compatible spreadsheet data reduction suggestions provided in current SUM, Section 5.4.4 also should be copied to standard SPM, Section 1.2.

1.3 Document Overview. The purpose of each section in the SPM needs to be described in standard SPM, Section 1.3. Also included should be a listing of all RADGUNS documentation distributed with the model which is listed in current SUM, Section 1.1 under the heading "Hardware and Software."

2.0 REFERENCED DOCUMENTS

The majority of referenced documents for a standard SPM (and SAM) will be based on information in the MDM. However, the MDM does not have a list of referenced documents. Apparently, a list is being compiled for the next RADGUNS release. Numerous references are cited, but are modified by the phrase "to be addressed later." The list compiled for future model releases should be subdivided as necessary into one for a standard SPM and one for a standard SAM. Each reference in standard SPM, Section 2.0 should have a unique reference number.

3.0 PROGRAMMING ENVIRONMENT

3.1 Equipment Configuration. Host computer systems and additional software required to exercise the full model capability are described in Section 1.1 of the MDM. It states under the header "Hardware and Software" that RADGUNS has been hosted on machines manufactured by DEC (VMS and UNIX), IBM (VM), SUN (UNIX), and IBM-compatible PCS (MS DOS). However, that section did not list Silicon Graphics platform with a UNIX Operating System (OS) as a host environment which is so stated on current SUM, Section 2.1. This information should be included in standard SPM, Section 3.1.

3.2 Operational Information. Disk storage requirements for the distributed simulation and its input and output data sets are not cited in the current documentation. A description of external disk storage requirements should be developed for inclusion in the standard SPM, Section 3.2. Core memory requirements are alluded to in the current SUM, page 2, as "Storage: approximately 600K". Whatever the memory requirements are for execution should be stated in standard SPM, Section 3.2. Memory utilization examples should be included to illustrate requirements for simple studies as well as for complicated memory-intensive studies.

3.3 Compiling and Linking Instructions. An ANSI Standard FORTRAN 77 compiler is needed to compile and link RADGUNS. Current SUM, Sections 2.7.6 - 2.7.9 present instructions for compiling and linking RADGUNS on a variety of platforms. However, instructions to compile RADGUNS is not stated for a VAX/VMS system and only linking instructions are provided. Although compiling may not be technically challenging, a complete set of compiling and linking instructions should be provided in standard SPM, Section 3.3 for all host platforms.

4.0 PROGRAMMING INFORMATION

4.1 Introduction. Current SUM, Section 1.2.3 is titled "Organization of the RADGUNS Weapon System Simulations." It describes the primary simulation files which indicates a method of simulation subdivision at the top level. No description is provided about the history of programming style evolution. MDM, Section 1.4 "Historical Background" should be used as a basis to describe any programming style and convention that can be correlated with various stages in the model evolution. This should be included in standard SPM, Section 4.1. One programming convention that should be mentioned is that

global variables generally are not grouped in a single block; rather, each common block generally is named the same as the single variable that it contains.

4.2 Call Hierarchy. MDM, Section 2.8 "Source Code Hierarchy" should be included in standard SPM, Section 4.2. It presents a high-level call hierarchy and briefly describes each subroutine in the hierarchy.

4.3 Dictionary of Variables. Appendix B of the MDM is titled "Dictionary of Principal Variables." It lists and defines a select set of variables. Units of measure are provided for some of the variables. This partial list is a good basis for generating an alphabetical list of all RADGUNS variables with units of measure, usage as a local or global variable, and the common block containing the variable if different than the variable name. The majority of RADGUNS common variables are in common blocks of the same name. The standard SPM, Section 4.3 should contain the variable list.

4.4 Global Variables. Global variables are contained in common blocks for programs written in the FORTRAN language. An alphabetical listing of common variables and the modules that utilize the variables is not provided in the current documentation. However, some of this information is scattered throughout methodology descriptions in the MDM. A complete alphabetical list with a description of each global variable used in RADGUNS needs to be generated for standard SPM, Section 4.4. The modules in which each common block appear should also be included in the list.

4.5 Program, Subroutine, and Function Descriptions. Excellent module descriptions are in the MDM with minor exceptions. The only improvement needed is the identification and description of all variables (including commons) used by a module. These improvements should be incorporated per 4.5.d in the SPM requirements described earlier in Section 5.2.2.1 "Standards." Figure 5-1 depicts how a module description could be formatted for inclusion in the SPM. The MDM, Appendix C Title Page is incorrectly labeled "Appendix III." Hereafter, the final appendix of the MDM will be referred to as Appendix C and it contains 237 pages of RADGUNS module descriptions. These should be incorporated in standard SPM, Section 4.5

4.6 Error Detection and Diagnostic Features. Error messages and diagnostics are not provided in the distributed model documentation. Detailed descriptions of each error, the module(s) in which the error occurred, the code variables involved with the error, and conditions causing the error should be included in standard SPM, Section 4.6. These diagnostics should be detailed, programming-related explanations of those briefed in standard SUM, Section 4.0.

5.0 TERMS AND ABBREVIATIONS

A glossary of terms and abbreviation definitions are not in the current MDM. These should be generated for inclusion in standard SPM Sections 5.1 and 5.2, respectively.

APPENDIX A: DETAILED CALL HIERARCHY

A detailed call hierarchy should be developed for standard SPM, Appendix A.

FUNCTION NAME: RADVEL

1. Brief Description: Computes the radial velocity of an object with respect to the radar.

2. Calling Sequence: X = RADVEL (P,RANGE)

3. Security Classification: Unclassified

4. Program Size: 8 lines

5. Location: File RAD1.FOR, Line 876

6. Calling Environment

   Calls: DOT

   Called By: ENDRUN, HITPRB, PERCUE, SIGNL, SRCH1, SRCH2

7. Common Blocks: SWIND/SWIND

8. Variables:

Name	Usage	Dim	I/O	Type	Definition	Units
P	arg	3,3	x	R	pos, vel, acc of object	m, m/s, m/s2
RANGE	arg	1	x	R	range to object	m
SWIND	com	1	x	R	wind speed against object	m/s
XDUM	loc	1	---	R	dummy variable	---
K	loc	1	---	I	do-loop index	---

9. Discussion and Formulation:

   The position vector P of the object is stored in P(1,1), P(2,1) and P(3,1), while the velocity vector V of the object is in P(1,2), P(2,2) and P(3,2). The radial velocity of the object is:

$$RADVEL = \frac{V \quad P}{R}, \text{ where R is the range to object}$$

FIGURE 5-1. Example of Summary Subroutine Description.

5.2.3 Software Analyst's Manual

The purpose of the SAM is to describe the functional structure and algorithms of a model. It should describe the purpose and background of the model in general terms and give detailed technical descriptions of its complete capabilities, structure, and functions. These detailed descriptions should divide the capabilities of the model into the major functions it performs. All equations, algorithms, and decision processes used by each major function should be described in detail. Details also should be given about model assumptions, limitations, and flexibility (e.g., ability to address different types of problems). Inputs and outputs should be described in words rather than file formats. Each module should be described in great detail to explain the correlation between the modules and model functional descriptions. The SAM enables the user to understand the theoretical basis of the model. The user needs it to facilitate understanding of the code and to ensure that the model is appropriate for particular analysis requirements.

5.2.3.1 Standards

The recommended format for a SAM is described in [Ref. 36] and repeated below:

> **Title Page and Preliminary Information**. The SAM Title Page should include the following information: Model Name, Version Number, Volume Number (if applicable), Development Agency, Contractor Name and Address, Contract and CDRL Numbers (if applicable), Date Published, Distribution and Destruction Notices (if applicable), and Document Control Number (DCN). The term "Prepared by" should precede the listing of the Contractor Name and Address. In addition to the Title Page, sections covering a Foreword (Abstract), Table of Contents, List of Tables, and List of Figures should also be provided.
>
> **SECTION 1: SCOPE**
>
> **1.1 Identification**. Identify the exact model title, its acronym or abbreviation, the version number, and any other official model identification information.
>
> **1.2 System Overview**. State the purpose of the model. Include its mission, a general description of the physical systems simulated, and a general description of the intended scenarios. Discuss the types of problems addressed and types of answers provided by the model. Provide overviews of all major modes of operation and scenarios corresponding to each mode. Auxiliary programs used to generate input data or process output data should be acknowledged and described.
>
> **1.3 Document Overview**. List and describe the purpose of each section of the SAM. Also identify any other documents in the document set containing the SAM.
>
> **SECTION 2: REFERENCED DOCUMENTS**
>
> List the title, number, author, publisher, date, and classification level (unless all are unclassified) for each document used in generating the SAM and for all known documentation for this model. Include sources for all documents not available through normal government stocking activities.
>
> **SECTION 3: FUNCTIONAL DESCRIPTION**
>
> **3.1 Overview**. Describe the model's complete functionality without reference to implementation methodology. These descriptions should elaborate on the overall mission and major modes described above in Section 1.2 "System Overview." Descriptions should be presented in the order functional methodologies are described in the sections that follow.
>
> **3.2 General Modeling Approach**.
>
> **3.2.1 Assumptions and Limitations**. Describe high-level assumptions and limitations of overall model functionality.

3.2.2 Overall Modeling Methodology. Explain how assumptions, limitations, and the processes involved influence the general modeling methodology.

3.3 Detailed Functional Implementation Methodology. Describe how the capabilities of the model are functionally implemented. Divide this section into subsections corresponding to the model's major areas of functionality; provide the following information for each subsection:

a. Equations and Algorithms. Provide detailed technical descriptions and purposes for use of specific empirical and analytic equations, numerical algorithms, and decision processes used by the function. Use flow diagrams to depict the implemented logic and use illustrations to depict geometrical considerations when appropriate. Justify use of specific probability distributions. When trade-off studies for equation usage were performed, justify use of the chosen equation.

b. Equations for Variables. Present and describe all equations (using mathematical notation) used for calculating variables that are significant in the implementation of the functionality. Indicate the code variable names that correspond with the variables described by these equations.

c. Model Inputs and Outputs. Inputs and outputs relevant to a particular area of functionality should be described in words without reference to code implementation details. Identify the relationship of inputs to the equations and algorithms in one of those areas.

d. Code Module Correlation with Functionality. Identify each module used to implement an area of functionality and describe the processes contained in that module. The description of each module should include its purpose and a detailed technical explanation. Correlate these processes with the model functional descriptions. Applicable library functions may simply be listed with a short description.

e. Impact on Model Results. Describe the impact of the functionality on model results.

SECTION 4: NOTES

4.1 Glossary of Terms

4.2 Abbreviations

APPENDICES. Appendices may be used for ease in document maintenance, examples and illustrations to assist in understanding model capabilities, or for readability of the core text material. Examples of appendix contents are logic flow diagrams, sample user interface printouts, examples of post-processor use, former studies published using this model, and any classified appendices.

APPENDIX A: DETAILED ASSUMPTIONS AND LIMITATIONS

Appendix A is reserved for describing all model assumptions and limitations. These should be organized by major areas of functionality. This appendix is the same as Appendix A of the SUM.

5.2.3.2 Assessment

A SAM for RADGUNS was not produced. However, the MDM contains much information about the modeled processes. In fact, the majority of MDM information is most applicable to the SAM (the MDM appendices apply to the SPM). Most of the included discussions can be copied to subsections of the standard SAM and trimmed or elaborated upon as necessary. Of course, topics not discussed in the MDM will need to be generated for the standard SAM. The following paragraphs contain comments regarding the SAM requirements described in Table 5-4.

Title Page and Preliminary Information. The SAM Title Page and preliminary information should be written per instructions presented earlier in Section 5.2.3 except that the information should be applicable to the SAM.

1.0 SCOPE

1.1 Identification. The model identification information is in current SUM, Section 1.1 "Outline of Simulation Capabilities." The headings of "Title, Proponent, and Point of Contact" from that section should be copied to Section 1.1 of a standard SPM. The applicable version is stated as Version 2.0 Beta, 2/96, under the "General Data" header. The version should be included with the model title.

1.2 System Overview. Some system overview information is contained in the current SUM, Section 1.1 under the headers of "Purpose and Description." Section 1.2 "Types of Simulations" provides a very brief discussion of major modes of operation with corresponding scenarios. Section 1.2.1 "Major Components of a Weapon System" and Section 1.2.2 "Weapon System Operation" should be included in standard SAM, Section 1.2. Sections 2.3.1 - 2.3.5 "Types of Simulations" overview user-selectable operational capabilities. For example, the user may select to investigate only target detection range with no tracking or gun firing. The paragraphical descriptions of these five sections also should be included in standard SAM, Section 1.2.

MDM, Section 1.3 "Mission," Section 1.5.1 "Purpose of Model" and Section 1.5.2 "Operational Capabilities" should be copied to standard SAM, Section 1.2. Section 1.5.2 really is a list of weapon systems modeled and should have a subsection named as such in standard SAM, Section 1.2. MDM, Section 3.5 "Major Components" provides a good overview of major modes of operation, top-level modeled systems (hereafter called major components) and general associated scenarios; the code implementation references should be deleted after copying it to standard SAM, Section 1.2.

MDM, Section 1 "Introduction" alludes to types of problems addressed and answers provided by RADGUNS. These should be explicitly stated in standard SAM, Section 1.2. Also, current SUM, Section 2.4 "Types of Probability of Kill Calculated" should be included with such discussion.

Discussion of several post-processors in current SUM, Sections 2.8 through 2.13 should be briefly reviewed in standard SPM. IBM PC-compatible spreadsheet data reduction suggestions provided in current SUM, Section 5.4.4 should be copied to standard SAM, Section 1.2.

1.3 Document Overview. The purpose of each section in the SAM needs to be described in standard SAM, Section 1.3. Also included should be a listing of all RADGUNS documentation distributed with the model which is listed in current SUM, Section 1.1 under the heading "Hardware and Software."

2.0 REFERENCED DOCUMENTS

The majority of referenced documents for a standard SAM will be based on information in the MDM. However, the MDM does not have a list of referenced documents. Apparently, a list is being compiled for the next

RADGUNS release. Numerous references are cited, but are modified by the phrase "to be addressed later". The list compiled for future model releases should be subdivided as necessary into one for a standard SPM and one for a standard SAM. Each reference in standard SAM, Section 2.0 should have a unique reference number.

3.0 FUNCTIONAL DESCRIPTION

3.1 Overview. An overview of the model's functionality is in MDM, Sections 2.6 and 2.7 "Logic Flow Through Major Components" and "Data Flow Through Major Components," respectively. However, only three major components are the subject of these sections. Section 2.5 "Major Components" lists seven major components. Sections 2.6 and 2.7 seem to not present the intended depiction the entire model, but they should. An overview of the model's complete functionality should be included in standard SAM, Section 3.1 without reference to implementation.

3.2 General Modeling Approach

3.2.1 Assumptions and Limitations. MDM, Sections 1.5.3 and 2.4 both are titled "Assumptions and Limitations." These are appropriate high-level statements that should be included in standard SAM, Section 3.2.1. Current SUM, Section 1.3 defines the inertial and the target frames of reference which is an exact copy of MDM, Section 2.4.2 "Coordinate Frames." Section 2.4.1 is a single statement that RADGUNS is more effectively used for relative rather than absolute lethality and survivability assessments. This sentence is followed by the frequently used phrase "More to be added." Thus, an apparent plan for future releases is to document more high-level assumptions and limitations. All high-level assumptions and limitations should be included in standard SAM, Section 3.2.1. A detailed comprehensive discussion of assumptions and limitations should be included in Appendix A of the standard SAM (same as Appendix A in the standard SUM).

3.2.2 Overall Modeling Methodology. MDM, Section 2.2 "Levels of Modeling" is most applicable to standard SAM, Section 3.2.2. It describes the level of detail (fidelity) of modeling for eight total "subsystem models" presented in Table 2-1. Some of these are cited major components while some major components are missing from the table (electronic countermeasures (ECM), electronic counter-countermeasures (ECCM), end game). Several subsystems are not represented in the table. This table is an inference to how assumptions influenced the modeling methodology; however, a section needs to be generated that explains how assumptions, limitations, and the processes involved influence the general modeling methodology. This should be included in standard SAM, Section 3.2.2.

3.3 Detailed Functional Implementation Methodology

Preliminary statements about the MDM detailed methodology descriptions (Sections 3 and greater) will be helpful in understanding the recommended parsing of information into a standard SAM.

The MDM has discussion of top-level modeled processes in Section 2 "Top-Level Design." Sections 3 through 9 elaborate on aspects of the top-level

methodology. Major components are subdivided by subfunctions called "functional elements (FEs)" in the MDM. The definition of a FE is not provided. Based on the MDM, a FE seems to be any portion of a major component. For example, Section 3.3.1 is called "Introduction and Functional Element Description." It describes the Acquisition Radar Receiver "Functional Element." Moving Target Indicator (MTI) and Antenna Gain are subfunctions of the acquisition radar; yet, these subfunctions also are cited as FEs. Section 3.6 "Track Radar Receiver" begins with the Introduction and Functional Element Description for Angle Tracking. Therefore, the MDM does not include the track radar as a FE; although, the acquisition radar is described as a FE. Track-radar-level methodology description is missing from the MDM. The assessment below is based on the information provided in the MDM for Version 2.0. An implicit recommendation is that all modeled processes in RADGUNS should be completely described in a SAM as specified earlier in Section 5.2.3.1.

The format and content of the methodology descriptions is not consistent in the MDM. Several titles are used for sections used as introductions to functionalities. Some of these are: "Introduction and Functional Element Description," "Introduction and Functional Element Design," and "Functional Description." Many functionalities are further described in subsections such as: "(FE name) Functional Element Design Requirements," "(FE name) Functional Element Design Approach," "(FE name) Functional Element Software Design," "Relationship of Functional Element to Whole Model," "Assumptions and Limitations," and "Known Problems and Anomalies." Not all of the above subsections are included for each functionality. In fact, significant variances in format and content has occurred. For example, Section 5.2 "Gun Ballistics" has only two subsections: Section 5.2.1 "Background Theory" and Section 5.2.2 "Methodology." Section 5.3 "First-Order Fire Control Computers" has nine pages of derivations combined with some of the information in typical subsections of other components; but, no subsections occur under MDM, Section 5.3. Sometimes the "Assumptions and Limitations" and "Relationship of FE to Whole Model" sections are a subsection of the Functional Element Software Design; but, usually they each are at the same paragraph level. In general, the MDM is not a well-structured document. This could be due to an on-going process of revision which was not complete at the time of the MDM publication.

Deficiencies identified in the current manuals are based on standard SAM requirements. An implied recommendation for categories of information assessed as missing is that the information needs to be developed for inclusion in a standard SAM. A complete standard SAM will require the developer to identify all modeled functionalities not currently described, and provide all details identified in Section 3.3 of the standard SAM. The details for each functionality should be made adequate for the level of fidelity of the modeled functionality.

In the assessments that follow, inclusion of MDM material in the standard SAM will be referenced by MDM section titles since many (but not all) sections have similar groups of information. Standard SAM, Section 3.3 should have detailed methodologies initially subdivided by major component, just as in the MDM.

Subfunctions (FEs) should be the topics of each major component subsection. A brief verbal description should first be provided to define the scope of functionality for each FE. Such descriptions are already provided for most currently-described FEs under the headers of "Introduction and Functional Element Description," "Introduction and Functional Element Design," and "Functional Description." Of course, not all introductory descriptions are included for all FEs; therefore, some will need to be generated to attain a complete standard SAM. After each FE introductory description, information related to each list item below should be provided. MDM subsections applicable to the following list items are provided next.

a. Equations and Algorithms. Subsections beginning with a FE name followed by: "Design Approach", "Background Theory", or "Theory" have good explanations of equations and algorithms that are used in the modeling of an FE. Other detailed descriptions, such as those for fire-control computers (FCCs), have many equations and algorithms not within subsections. In any case detailed technical descriptions and purposes for use of specific empirical and analytic equations, numerical algorithms, and decision processes used by the function should be included in standard SAM, Section 3.3. MDM figures are usually either flow diagrams, call hierarchies, or graphical representation of geometries or model output. Those MDM figures containing flow diagrams to depict the implemented logic and figures with illustrations to depict geometrical considerations should be included with the equation and algorithm descriptions. Flow diagrams also should accompany the applicable equations and algorithms. For those FEs not currently described, justification for use of specific probability distributions should be provided. When trade-off studies for equation usage were performed, justification for use of the chosen equation also should be provided.

b. Equations for Variables. MDM subroutine flow diagrams have blocks that often represent code variable calculation and many cited variable calculations are referenced to numbered equation(s) stated earlier in the FE description. However, some code variables significant in the implementation of the FE functionality do not have equations associated with them; all such descriptions should be included in standard SAM, Section 3.3.

c. Model Inputs and Outputs. Input to and output from subfunctions are in the MDM methodology descriptions. The classified Supplement to User Manual [Ref. 38] describes the majority of RADGUNS system data. Sections 2 and 3 are model input data for weapon systems and targets, respectively. These should be combined into a single SAM appendix and should be referenced in the unclassified methodology descriptions in the SAM. The relationship of inputs and outputs to each area of functionality should be developed for inclusion in standard SAM, Section 3.3.

d. Code Module Correlation with Functionality. Many MDM FE descriptions have subsections detailing FE software design. Call

hierarchies specialized to modules implementing specific FEs are usually included in those subsections. The hierarchies are good indicators of applicable modules and their interrelationships. The hierarchy is not required for this section of a standard SAM; yet, it is an excellent way of identifying modules. Detailed description of module processes and how they implement the intended functionality is provided in MDM subroutine flow charts with descriptions and these should be included in standard SAM, Section 3.3. For FEs that are documented at a future date, such descriptions should be developed for all modules for each subfunction.

e. Impact on Model Results. Four FE descriptions in the MDM have subsections titled "Relationship of FE to Whole Model". These four subsections should be included with their respective FE descriptions in standard SAM, Section 3.3. For all other model FEs described in the MDM, the effects that particular areas of functionality have on model results is often inferred. The impact should be clearly stated for all FEs in standard SAM, Section 3.3.

Current SUM, Section 3.1 is called "The Target Model." It provides target representation methodologies related to orientation, RCS, presented area, and vulnerable area calculation. Current SUM, Section 3.1 information should be included in standard SAM, Section 3.3 as a unique major component. The descriptions should be modified to fulfill requirements of the standards described earlier in Section 5.2.3.1. Also, the Supplement to the SUM has methodology descriptions related to ECM/ECCM which should be included a classified appendix of model methodology.

4.0 TERMS AND ABBREVIATIONS

A glossary and terms of abbreviations is not provided in the MDM. A glossary of terms and an identification of abbreviations should be included in standard SAM, Sections 4.1 and 4.2, respectively.

APPENDIX A: DETAILED ASSUMPTIONS AND LIMITATIONS.

Sections 1.5.3 and 2.4 of the MDM are both titled "Assumptions and Limitations". These are general discussions of system- and model-level assumptions and limitations. Detailed assumptions and limitations are presented in separate subsections in the methodology descriptions after Section 2 of the MDM. These descriptions are subdivided by subfunctions of modeled systems. Standard SAM Appendix A should have assumptions and limitations organized by areas of functionality. Thus, all high-level assumptions and limitations should be subdivided and the detailed ones should be included as subparagraphs of those at higher level. Only a partial list of assumptions and limitations is in the current documentation. A detailed comprehensive discussion of all assumptions and limitations should be included in Appendix A of the standard SAM (same as Appendix A in the standard SUM).

Other Appendices

A single classified volume should be named to indicate that it is a supplement to the RADGUNS SAM and should contain two appendices. One should have

the classified system data, while the other should have classified methodology descriptions related to ECM and ECCM.

5.3 RECOMMENDED MODIFICATIONS

The sections that follow describe the changes needed to bring documentation applicable to RADGUNS Version 2.0 into compliance with the standards recommended in Ref. 36. Table entries provide estimates of the number of additional pages (based on the current manuals page count) needed to complete such recommendations. Comments are also included in these tables regarding what recommendations are being made. These estimates are a rough order of magnitude (ROM) based on the current understanding of RADGUNS documentation. Wherever possible, the page estimates are based on treatments of similar topics in the documentation or in the documentation of other models.

5.3.1 Software User's Manual

The current SUM is very close to fulfilling all the requirements for a standard SUM. Table 5-5 presents a summary of the recommendations from the above discussions to achieve SUM compliance with the proposed documentation standards.

TABLE 5-5. Estimated Number of New Pages for RADGUNS SUM.

Section/Topic	Number of New Pages	Recommendations
Title Page and Preliminary Information	1	Generate list of tables/figures. Merge Preface/Executive Summary into Foreword.
1.1 Identification	0	Move from Section 1.1.
1.2 System Overview	0	Extract from SUM, Sections 1.1, 1.2, 2.3.1-2.3.5, 2.8-2.13, and 5.4.4 and from MDM, Sections 1.3, 1.5.1, 1.5.2, and 3.5.
1.3 Document Overview	1	Generate from scratch.
2.0 Referenced Documents	0	Move from SUM, Pages 102 and 105.
3.1 Initialization	0	Move from SUM, Section 2.7.
3.2 User Inputs	0	Move from SUM, Sections 2.6.1, 2.6.2, 3.1.2, 3.1.3, 3.1.4, 3.2, 3.3.
3.3 Links to Other Programs	0	Move from SUM, Sections 2.8-2.13, 5.4.4.
3.4 Outputs	2A	Move from SUM, Sections 3.4; add remainder based on Sections 2.5 and 3.4 (A= # of output files not described).
4.0 Error Messages/Actions	E/4	Generate from scratch (E = # error messages not described).
5.0 Terms and Abbreviations	2	Move from current SUM, Page 103.
Appendix A: Detailed Assumptions and Limitations	F/10	Copy from MDM, Sections 1.5.3, 2.4, and scattered among Sections 3 through 9 (F = # of assumptions and limitations not mentioned).
Other Appendices	0	Use appendices for MAR., unit conversions, and sample outputs.

5.3.2 Software Programmer's Manual

No SPM was generated for RADGUNS v.2.0. Much information applicable to the SPM is in the MDM. SPM-related information missing from the current MDM includes description of detailed module call hierarchy, dictionary of variables, and error detection and diagnostic features. Table 5-6 presents a summary of the recommendations from the above discussions to generate a SPM that complies with the proposed documentation standards.

TABLE 5-6. Estimated Number of New Pages for RADGUNS SPM.

Section/Topic	Number of New Pages	Recommendations
Title Page and Preliminary Information	1	Generate list of tables/figures. Merge Preface/Executive Summary into Foreword.
1.1 Identification	0	Move from SUM, Section 1.1.
1.2 System Overview	0	Extract from SUM Sections 1.1, 1.2, 2.3.1-2.3.5, 2.8-2.13, and 5.4.4 and from MDM, Sections 1.3, 1.5.1, 1.5.2, and 3.5.
1.3 Document Overview	1	Generate from scratch.
2.0 Referenced Documents	1	Generate from scratch
3.1 Equipment Configuration	0	Move from SUM, Section 2.1 and MDM, Section 1.1.
3.2 Operational Information	2	Write discussion on external and core memory requirements. Provide memory utilization examples.
3.3 Compiling and Linking Instructions	1	Move from SUM, Sections 2.7.6 - 2.7.9. Add compiling instructions.
4.1 Introduction of Programming Information	3	Mostly generated from scratch. Include SUM, Section 1.2.3.
4.2 Call Hierarchy	0	Move from MDM, Section 2.8.
4.3 Dictionary of Variables	15	Copy from MDM, Appendix B and modify to include all RADGUNS variables.
4.4 Global Variables	25	Develop a common block definition list based on subroutine descriptions in MDM.
4.5 Program, Subroutine and Function Descriptions	N/3	Move from MDM, Appendix C. Add module descriptions as necessary (N = number of modules not described in Appendix C).
4.6 Error Detection and Diagnostic Features	n/2	Generate from scratch (n = number of diagnostics not described).
5.0 Terms and Abbreviations	3	Create from scratch.
Appendix A: Detailed Call Hierarchy	20	Create from scratch.

5.3.3 Software Analyst's Manual

No SAM was generated for RADGUNS Version 2.0. Much information applicable to the SAM is in the MDM. SAM-related information missing from the current MDM includes functional implementation methodology description for all RADGUNS subfunctions. A significant number of detailed methodology descriptions needs to be generated to fulfill all requirements for a standard SAM. Table 5-7 presents a summary of the recommendations from the above discussions to generate a SAM that complies with the proposed documentation standards.

TABLE 5-7. Estimated Number of New Pages for RADGUNS SAM.

Section/Topic	Number of New Pages	Recommendations
Title Page and Preliminary Information	1	Generate List of Tables/Figures. Merge Preface/Executive Summary into Foreword.
1.1 Identification	0	Copy from SUM, Section 1.1.
1.2 System Overview	0	Extract from SUM, Sections 1.1, 1.2, 2.3.1-2.3.5, 2.8-2.13, and 5.4.4 and MDM, Sections 1.3, 1.5.1, 1.5.2, and 3.5.
1.3 Document Overview	1	Generate from scratch.
2.0 Referenced Documents	1	Generate from scratch.
3.1 Functional Description Overview	3	Move from MDM, Sections 2.6 and 2.7.
3.2.1 Assumptions and Limitations	2	Mostly new. Some can be copied MDM, Sections 1.5.3 and 2.4.
3.2.2 Overall Modeling Methodology	10	Mostly new. Some discussion in MDM, Section 3.2.2.
3.3 Detailed Functional Implementation Methodology		
a. Equations and Algorithms	W/2	Move from MDM sections on Design Approach, Background Theory, or Theory. (W = number algorithms not described).
b. Equations for Code Variables	X/2	Base on MDM flow diagram descriptions (X= number equations not provided for variables).
c. Inputs and Outputs	Y/2	Develop descriptions for inputs and outputs to subfunctions (Y = number of subfunctions not currently described in MDM).
d. Module Correlation with Functionality	Z/2	Extract from software design subsections in MDM (Z = number of modules associated with subfunctions not described in MDM).
e. Impact on Model Results	B/2 - 2	Move the 4 MDM sections labeled "Relationship of FE to Whole Model." Extract from MDM methodology descriptions and write new material as necessary.
4.0 Terms and Abbreviations	3	Create from scratch.

TABLE 5-7. Estimated Number of New Pages for RADGUNS SAM.

Section/Topic	Number of New Pages	Recommendations
Appendix A: Detailed Assumptions and Limitations	F/10	Copy from MDM, Sections 1.5.3, 2.4, and scattered among Sections 3 through 9 (F = # of assumptions and limitations not mentioned).
Other Appendices	0	Move from classified Supplement to SUM, Section 2,3, and 4.

Neither a SPM nor a SAM was delivered with RADGUNS; although, the MDM encompasses much of the required information for a SPM and SAM. As was mention earlier, the MDM is not a well-structured document. This could be due to an on-going process of incremental revision which was not complete at the time of the MDM publication. Certainly, continuous documentation improvement is commendable. This publication presents an as-is assessment at a specific period in model development, and the suggested improvements are meant to help the authors attain an accurate, complete, and easily-readable document.

This documentation assessment does not encompass verification that all statements in the manuals are an accurate representation of the code; however, some documentation errors were noted during the assessment. These are described next.

The current SUM Preface states that the three delivered manuals are a complete set of the SUM, SAM, SPM manuals for RADGUNS. This is incorrect. The user should be cautioned that not all capabilities of the model are completely described. The bottom of SUM, page 2, has two duplicate headers and a duplicate sentence fragment, which should be deleted. Also, the header “2.6 Simulation Setup” is omitted from the text and should be included. The Supplement to User Manual, Section 1.2.10 states “All corrections/improvements suggested by the SMART Program to date have been incorporated into this version of RADGUNS.” This statement should be deleted as it is incorrect. Select SMART Project improvements and corrections are applicable, but not all.

Page 1-3 indicates the latest version as being “1.9,12/94” which should be corrected. The model-level logic flow diagram (Fig. 2-2) depicts only a portion of the seven listed major components and it also is missing a “no” path from the bottom decision block (represented by a diamond-shaped block). Further, the decision block labeled “Beyond gun range and receding?” is only one of several possible simulation termination criteria, but, the block should reflect all possibilities.

Figure 2-3 depicts only a portion of seven major components. Subroutine BURST description on page 2-15 describes an array called “ProjectileQ.” FORTRAN allows only six letters per variable name. Page 3-2 has two subroutine descriptions missing from the table.

Figure 3-2 has two execution paths at the bottom of page 3-5, but the continuation of these on page 3-6 is discontinuous, as only one path is present at the top of page 3-6. Also, the

"no" decision path for final decision block on page 3-6 is labeled on a different block. The description for Block 9 of Figure 3-2 is an incomplete sentence.

The first occurrence of Section 3.3.3.3 (page 3-7) should be changed to 3.3.2.3. Also, that section states that subroutine SRCH1 has two output variables, which is incorrect. It has two subroutine arguments that serve as values returned to the calling routine.

Figure 3-12 is a call hierarchy with two typographical errors. Modules labeled as AXDIFF and MATADO should be changed to AZDIFF and MATADD, respectively. Also, the description of Block 1 of Figure 3-13 cites Equation [7.1-2], which does not exist.

The acquisition radar receiver "functional element" encompasses the MTI subfunction at Section 3.3.3. This section also includes description of MTI for the track radar which should be reserved for Section 3.6.3 "Moving Target Indicator (Tracking Mode)." Figure 3-6 is titled "MTIACQ Functional Flow Diagram". Besides the typographical error, the title is wrong because the figure is not a subroutine flow diagram. Rather, it is a flow diagram depicting the relationship of MTI to the whole model. The same problem exists with Figure 3-17 which actually is a flow diagram depicting the relationship of MTI (for tracking) to the whole model. Another problem is apparently due to document configuration management practice. MTI code implementation seems to have changed between Version 1.9 and 2.0. Appendix C subroutine descriptions do not have a description for subroutine MTIRNG. A new subroutine, MTITRK, apparently has replaced the former subroutine MTIANG as is evidenced by the incorrect call sequence of "X = MTIANG (OMEGAD)". Neither MTIANG nor MTITRK is mentioned in the track radar MTI descriptions. A general recommendation is that the documentation in future releases should be comprehensively reviewed and modified as necessary to accurately reflect the subject model version. Should methodology descriptions only apply to a select system(s), the reader should be so advised. For example, the first paragraph of Section 3.6.3.2 states that during autotrack, MTI attenuation will be applied to the range channel only. The range channel restriction is only correct when associated with specific systems. However, when Subroutine MTIANG is necessary, then MTI attentuation is also applied to the angle channel.

The MDM document has a significant cross-referenceability problem. Many methodology descriptions have duplicate equation numbers. Certainly, specifying an equation number from a specific section would result in a unique equation; however, the document seems to be in a constant process of revision so an equation numbering convention should be developed to attain unique equation numbers throughout the manual set. Also, the following figure references are noted: in Section 3.7.3.2, the first paragraph references of "Figures 3-14 through 3-17" should be changed to "Figures 3-20 through 3-23". After the second paragraph, all references to Figures 3-17, 3-18, and 3-19 should be changed to 3-21, 3-22, and 3-23, respectively.

MDM (Pg 3-52) has a reference to Version 1.8 at the bottom of the description of Block 1. This should be deleted. Page 3-57, Equation [50], has two typographical errors: OMEGADB and RADVELB should be changed to OMEGAD and RADVEL, respectively. Equation [50] illustrates that some equations have a mixture of symbols and variable names. All detailed functional implementation methodology described in standard SAM, Section 3.3 should first be in mathematical notation independent of implementation. A separate description specialized to code implementation should then be included.

MDM, Section 5.2, Equations [11], [13], [14], [15], and the sentences above equations [11] and [12] have a significant typographical error (also a mathematical error). All references to “d2” should be changed to “d2”.

Section 7 does not mention the SALVO formula which is a significant part of the RADGUNS end-game capability. Page 7-5 has an incorrect calling sequence cited for Subroutine ORIENT.

MDM, Section 8.2.2 has a typographical error in its title. Figure 8-4 depicts Subroutines FIRCON and MOVGUN as being called by ENGAGE. This is true for former RADGUNS versions. The new names of the two modules called by ENGAGE are FCCOMP and MVGUN. In Table 8-4, “FCCOM” should be changed to “FCCOMP”.

MDM, Section 9.1.1 states that RADGUNS Version 1.8 offers a barrage noise jamming technique. Version 1.8 should be changed to Version 2.0.

MDM, Appendix C has the calling sequence of DGAM as “X= DGAM(8,N)”. The first argument should be changed to the letter “B”. Page C-149 has the extra word “sive” in the last sentence, which should be deleted.

5.3.4 Summary

A significant level of effort (LOE) will be required to generate three standard manuals as described in Section 5.2. Table 5-8 summarizes the estimated number of new pages required for each manual. In many cases, information from several separate sources must be incorporated smoothly into the manuals.

TABLE 5-8. Summary: Estimated Number of New Pages.

Manual	Additional Pages
SUM	4 + 2A + E/4 + F/10
SPM	72 + N/3 + n/2
SAM	19 + B/2 + W/2 + X/2 + Y/2 + Z/2
Total	95 + 2A + B/2 + E/4 + F/10 + N/3 + n/2 + W/2 + X/2 + Y/2 + Z/2

Notes:
A = # of output files not described
B = # of RADGUNS subfunctions
E = # of error messages not described
F = # of assumptions and limitations not described
N = # of modules not described
n = # of error diagnostics
W = # of algorithms not described
X = # of equations not provided for variables
Y = # of subfunctions not described in MDM
Z = # of modules associated with subfunctions not described in MDM

The documentation for RADGUNS will require much work to fulfill the recommended standards. The missing information will require a fairly large number of new pages. The most serious deficiencies in the SUM are the lack of a list of error messages and a comprehensive discussion of assumptions and limitation. The most serious SPM-related

deficiencies are the lack of an adequate description of error detection and diagnostic features, detailed call hierarchy, a dictionary of variables, and the discussion of global variables (common blocks). The most serious SAM-related deficiencies are that only a portion of the model functionality has methodology descriptions

A lot of the new pages will contain either a comprehensive call hierarchy or error detection and diagnostics. These are not as technically demanding as the theoretical discussions in an SAM; but, time to examine the code and write the descriptions will be required. The hierarchy is well-suited to generation by use of an automated computer-aided software engineering (CASE) tool. The most significant effort required to fulfill the standard documentation requirements probably will be the comprehensive identification and description of the theory and implementation of modeled processes of RADGUNS.

Model documentation is worth a significant expenditure of resources. The Military Operations Research Society (MORS) has included good documentation as a step in the model validation process [Ref. 5]. Development and use of standard documentation will increase user efficiency as well as model credibility.

5.4 IMPLICATIONS FOR V&V

The quality of the current RADGUNS documentation is assessed to be good for the included information. Extensive reformatting will be needed to achieve standardization; yet, this does not greatly impact V&V activities for the included information. However, an important task to facilitate future V&V will be to provide the information that currently is missing from the documents. The deficiencies have been identified throughout this documentation assessment. The impact of the deficiencies will be described next.

A comprehensive discussion of assumptions and limitations is needed to completely describe theoretical considerations of the modeled processes. A complete V&V of design approaches used to model the intended processes may be hindered without identification of assumptions and limitations. Of course, the lack of adequate detail in equation and algorithm description also will hinder the V&V of design approach. Input and output of subfunctions of modeled systems is important to help identify unique modeled entities at a fairly detailed level; input, processing, and output are important aspects to consider when assessing a modeled process. Citing applicable references for design approaches is another important documentation requirement which helps facilitate complete equation and algorithm verification.

Detailed file format descriptions, high-level and detailed call hierarchies, a dictionary of variables, and the discussion of global variables (common blocks) all are important to characterize the programming aspects of a simulation. These details are important to assess the code design to determine if the intended modeled processes are implemented in code correctly and are documented accurately.

5.5 IMPLICATIONS FOR MODEL USE

A model user could use a simulation incorrectly when information necessary to use the model is missing. For example, the absence of a discussion on assumptions and limitations could lead to improper program setup resulting in erroneous interpretation of output data.

A prospective model user needs a complete set of documentation to assess whether specific portions of a candidate model are simulated at a level detailed enough for specific analysis requirements.

RADGUNS documentation generally is detailed enough to assess the modeled subject's fidelity for the included subfunction descriptions. Of course, those undocumented functionality details could be difficult to assess for a novice user. The lack of adequate model execution error diagnostics could hinder the timely correction of problems.